

**KNOWLEDGE EXPECTATIONS FOR PEST CONTROL ADVISORS:
INSECT, MITES AND OTHER INVERTEBRATES**

I. IDENTIFICATION

A. Names of Arthropods & Related Organisms

Be prepared to identify the listed arthropods to class, order and family when given a name, specimen or photo of adult or immature forms. Know Latin names for class, order and a combination of common and Latin name for family. You will not be required to distinguish the difference between species in the same family.

For example: you do not need to recognize differences between the pear rust mite and the tomato russet mite, but you do need to know the difference between the pear rust mite and the citrus red mite (different families).

For each arthropod class and family listed, describe their:

- mouthparts and food habits;
- biology and life cycle;
- metamorphosis;
- significance as a pest or natural enemy;
- damage symptoms.

PHYLUM MOLLUSCA

CLASS GASTROPODA - Slugs and snails

brown garden snail

gray garden slug

decollate snail

PHYLUM ARTHROPODA

CLASS CRUSTACEA

ORDER ISOPODA - Sowbugs and pillbugs

CLASS DIPLOPODA - Millipedes

CLASS CHILOPODA - Centipedes

CLASS SYMPHYLA

ORDER SYMPHYLA - Symphylans

garden symphylan

CLASS ARACHNIDA

ORDER ARANEAE - Spiders

ORDER ACARI - Mites and Ticks

Family Eriophyiidae - Eriophyiid mites

pear rust mite

tomato russet mite

citrus bud mite

peach silver mite
Family Ixodidae - Hardbacked ticks
Family Phytoseiidae - Phytoseiid predatory mites
western predatory mite
Phytoseiulus persimilis
Family Tetranychidae - Spider mites
citrus red mite
European red mite
Pacific spider mite
twospotted spider mite

CLASS INSECTA

ORDER THYSANURA - Bristletails/silverfish and firebrats
ORDER COLLEMBOLA - Springtails
ORDER ODONATA - Dragonflies
ORDER ORTHOPTERA - Grasshoppers, crickets, katydids
Family Acrididae - Grasshoppers
Family Tettigoniidae - Katydids
ORDER BLATTODEA - Cockroaches
Family Blattidae - Oriental and American cockroaches
ORDER MANTODEA - Mantids
Family Mantidae - Mantids
ORDER DERMAPTERA - Earwigs
ORDER ISOPTERA - Termites
ORDER THYSANOPTERA - Thrips
Family Thripidae - Common thrips
citrus thrips
western flower thrips
greenhouse thrips
sixspotted thrips
ORDER HEMIPTERA (HETEROPTERA) - True-bugs
Family Anthocoridae - Minute pirate bugs
Family Coreidae - Leaffooted bugs
squash bug
Family Lygaeidae - Chinch bugs
bigeyed bugs
false chinch bug
Family Miridae - Plant bugs
western tarnished plant bug (lygus bug)
Family Nabidae - Damsel bugs
Family Pentatomidae - Stink bugs
conspire stink bug
Family Reduviidae - Assassin bugs
Family Tingidae - Lace bugs

ORDER HOMOPTERA - Aphids, scale insects, leafhoppers, treehoppers, and
others

Family Aleyrodidae - Whiteflies

greenhouse whitefly

citrus whitefly

silverleaf whitefly

ash whitefly

Family Aphididae - Aphids

cabbage aphid

green peach aphid

pea aphid

cotton/melon aphid

rosy apple aphid

potato aphid

lettuce root aphid

woolly apple aphid

spotted alfalfa aphid

Family Cercopidae - Spittlebugs or froghoppers

Family Cicadellidae - Leafhoppers

apple leafhopper

potato leafhopper

beet leafhopper

western grape leafhopper

variegated leafhopper

Family Cicadidae - Cicadas

Family Coccidae - Soft scales

brown soft scale

black scale

citricola scale

Family Diaspididae - Armored scales

oystershell scale

California red scale

San Jose scale

walnut scale

Family Margarodidae -

cottony cushion scale

Family Membracidae - Treehoppers

Family Phylloxeridae- Phylloxera

grape phylloxera

Family Pseudococcidae - Mealybugs

grape mealybug

citrus mealybug

obscure mealybug

Family Psyllidae - Jumping plantlice (psyllids)

pear psylla

potato psyllid

blue gum psyllid

ORDER NEUROPTERA - Lacewings

Family Chrysopidae - Green lacewings

Family Hemerobiidae - Brown lacewings

ORDER LEPIDOPTERA - Butterflies and moths

Family Gelechiidae - Gelechiid moths

peach twig borer

tomato pinworm

pink bollworm

potato tuberworm

Family Geometridae - Measuring worm moths

fall cankerworm

Family Lymantridae - Tussock moths

gypsy moth

western tussock moth

Family Noctuidae - Noctuid moths (cutworms)

cabbage looper

cutworms

tobacco budworm

alfalfa looper

corn earworm/tomato fruitworm/cotton bollworm

beet armyworm

western yellowstriped armyworm

Family Pieridae - Sulfur butterflies

alfalfa caterpillar

imported cabbageworm

Family Pyralidae - Snout moths

navel orangeworm

Family Sesiidae- Clear-winged moths

peachtree borer

ash borer

Family Sphingidae - Sphinx moths

tobacco/tomato hornworm

Family Tortricidae - Tortricid moths (leafrollers)

codling moth

oriental fruit moth

fruittree leafroller

omnivorous leafroller

spruce budworm

orange tortrix

ORDER COLEOPTERA - Beetles and weevils

Family Buprestidae - Metallic wood borers

Pacific flatheaded borer

Family Cerambycidae - Longhorned beetles

eucalyptus longhorned borer

Family Chrysomelidae - Leaf beetles

elm leaf beetle

asparagus beetle

western spotted cucumber beetles

tobacco flea beetle

Family Coccinellidae - Ladybird beetles

twicestabbed lady beetle

mealybug destroyer

convergent lady beetle

vedalia beetle

Family Curculionidae - Weevils and snout beetles

Egyptian alfalfa weevil

rice water weevil

Family Elateridae - Click beetles (wireworms)

Family Scarabaeidae - Scarab beetles (May or June beetles)

white grubs

Japanese beetle

Family Scolytidae - Bark beetles

western pine beetle

fir engravers

elm bark beetle

shothole borer

Family Tenebrionidae - Darkling beetles

confused flour beetle

ORDER DIPTERA - Flies, mosquitoes, gnats, midges

Family Agromyzidae - Leafminers

serpentine leafminer (*Liriomyza* sp.)

Family Anthomyiidae - Root maggot flies

cabbage maggot

seedcorn maggot

Family Cecidomyiidae - Gall midges/predaceous midges

Aphidoletes

Family Culicidae - Mosquitoes

Family Muscidae - House fly

Family Syrphidae - Syrphid or flower flies

Family Tachinidae - Tachinid flies

Family Tephritidae - Fruit flies

apple maggot

walnut husk fly
Mediterranean fruit fly
ORDER HYMENOPTERA - Bees, wasps, ants, sawflies, parasitoids
Family Aphelinidae - parasitoid wasps
Aphytis melinus
Encarsia formosa
Family Aphididae - parasitoid wasps
Trioxys pallidus
Family Apidae - Honey bees, bumble bees
Family Braconidae - Braconid wasps
Family Chalcididae - Chalcidid wasps
Family Formicidae - Ants
Argentine ant
southern fire ant
carpenter ants
Family Ichneumonidae - Ichneumon wasps
Hyposoter spp.
Family Tenthredinidae - Sawflies
California pear sawfly
purslane sawfly
Family Trichogrammatidae - Trichogrammatid wasps
Family Vespidae - Paper wasps and yellowjackets

B. Morphological characteristics of importance

List and describe the different types of mouthparts of insects.

List several insect orders that have:

chewing mouthparts;
piercing-sucking mouthparts.

Describe how piercing-sucking mouthparts are different from chewing mouthparts.

List the main body regions of adult:

insects;
spiders;
mites.

Recognize the following body parts on various groups of insects:

head;
prothorax;
mesothorax;
abdomen;
ovipositor;

spiracle;
femur;
tibia;
tarsus;
coxa;
trochanter;
antenna;
ocellus;
clypeus;
labrum;
mandibles;
palps,
forewings;
hind wings;
compound eye.

Recognize the following body parts on various larval forms of insects: abdomen;

thorax;
head;
prolegs;
crochets;
spiracles;
legs;
ocelli;
mandibles.

Identify and give examples of the following larval body types:

caterpillar (aeruciform);
scarab beetles (scarabaeiform);
wireworms (elateriform);
fly maggots (vermiform).

Explain the difference between armored scale and soft scale, and give an example of each.

II. ARTHROPOD BIOLOGY

A. Physiology

Describe how respiration in insect larvae and adults takes place.

Describe the reproduction process common to most insects.

Define parthenogenesis and give an insect example.

List the key functions of an insect's exoskeleton.

Describe the functions of the following insect hormones:

ecdysone;
juvenile hormone.

B. Life History

Describe and give an example of insects:

without metamorphosis;
with gradual/incomplete metamorphosis;
with complete metamorphosis.

Compare/contrast nymphs vs. larvae.

Describe the molting process in arthropods.

Define and give an example of:

aestivation;
diapause.

Define:

instar;
biofix point;
degree-days;
pheromones;
allomones;
semiochemicals.

List some insects for which degree-day models are useful in management programs, and describe how they are used.

Describe and give examples of two ways in which pheromones are used in an IPM program.

Define and give an example of a:

polyphagous insect;
monophagous insect.

Describe the mechanisms of dispersal and movement used by various arthropod species.

List and give examples of the different ways that insects overwinter.

III. ARTHROPOD ECOLOGY

A. Population Dynamics

Describe mortality factors and give examples of their impact on population dynamics.

List various factors which can limit insect:
development;
reproduction.

Describe the role of nutrition on insect development.

Describe the role of temperature/humidity on insect development.

Describe how reproduction affects population growth and dynamics.

Define the term carrying capacity.

Explain population regulation.

B. Biotic Factors

Define:

trophic structure;
host specificity.

Describe host range.

Describe the relationship of surrounding vegetation on pest populations.

Explain the importance of recognizing the different feeding habits in different arthropod life stages and give examples.

Explain the role of alternate hosts in relation to:
pest problems;
biological control;
virus vectors.

Describe the influence of nutrition on host quality.

Define and give an example of:
parasites;
parasitoids;
predators;
pathogens.

Explain the importance to biological control of knowing the: specificity of natural enemies;

broad host (prey) range of natural enemies.

C. Abiotic factors

Describe how the following abiotic factors can affect arthropod growth and development:

water stress;
nutrient availability;
dust;
weather;
pollution;
soil type.

IV. DAMAGE AND LOSS

A. Types of Damage

Compare/contrast the type of damage inflicted by insects with chewing mouthparts vs. piercing-sucking mouthparts.

Give some examples of arthropod species responsible for:

direct damage;
indirect damage;
damage from contamination;
damage that leaves an access for pathogen entry;
honeydew damage;
damage to crop quality;
cosmetic damage;
damage affecting photosynthetic storage.

Describe the influence of the following factors on damage to the plant host and loss of economic or aesthetic value:

plant compensation;
pest stage;
host stage;
induced resistance;
abiotic factors;
natural enemies;
relationship to plant pathogens;
markets.

B. Injury Levels

Explain how economic injury levels are originally developed.

Describe:

- economic injury levels;
- aesthetic injury levels;
- treatment thresholds;
- economic thresholds.

List various resources available to PCA's to keep abreast of changes in injury levels.

C. Sampling and Monitoring

List three patterns of distribution common to insect populations.

Describe how to determine the sampling method from the insect distribution.

Explain how sampling statistics help to determine:

- sampling efficiency;
- sampling accuracy.

Describe how the following factors influence choice of a sampling method:

- the pest species;
- the host;
- pest distribution patterns;
- the cost of sampling;
- crop value;
- sampling tool.

Compare/contrast the use of absolute/relative sampling techniques.

Describe:

- presence/absence sampling;
- sequential sampling.

Identify the following sampling tools and give an example of an arthropod pest typically monitored using:

- knockdown (beat sheet);
- leaf counts;
- sweep-net;
- light traps;
- sticky traps;
- D-Vac vacuum devices;
- pheromone traps.

Describe and assess the value of clues such as plant damage, frass, and honeydew for indicating pest population presence and damage potential.

V. MANAGEMENT

A. General Approaches

Define and give an example of the appropriate use of the following pest management strategies:

- IPM;
- organic;
- quarantine;
- eradication/total population management.

B. Host Plant Resistance

Define host plant resistance.

List examples of arthropod pests managed using host plant resistance.

Describe the use and give some examples of transgenic plants used for the control of arthropod pests.

Describe some limitations of transgenic plants in the control of arthropod pests.

Define biotypes and give an example of why they are problematic.

C. Biological Control

Explain population regulation.

Define and give an example of:

- classical biological control;
- conservation and enhancement biological control;
- augmentative biological control.

Identify common pest organisms attacked by the following natural enemies:

- convergent lady beetle;
- green lacewing;
- Aphytis melinus*;
- Hyposoter* spp.;
- syrphid fly larvae;
- assassin bugs;
- bigeyed bugs;
- Trichogramma* spp.;
- mealybug destroyer;
- Encarsia formosa*;

western predatory mite;
Phytoseiulus persimilis;
vedalia beetle.

Compare/contrast the life cycle of a parasitoid vs. a predator.

Describe the following successful biological control introductions in California:

vedalia beetle;
Trioxys pallidus (walnut aphid parasite).

Describe how the following techniques can be used to conserve natural enemies:

ant control;
strip cropping;
border harvesting;
selective pesticides;
spot treatments with pesticides;
alternate hosts.

D. Cultural Control

Describe the following cultural control techniques and give an example of an arthropod pest that each method aids in controlling:

leaf removal;
plow down;
host free period;
early harvest;
planting date;
water management;
fertilizer management.

E. Mechanical/Physical Control

Describe the use of the following mechanical/physical control techniques and give an example of a pest each method aids in controlling:

sticky traps;
mass trapping;
flooding;
row covers;
reflective mulches;
greenhouse vent screening;
discing/cultivation.

F. Sterile Insect Techniques

Describe the basis for effective use of sterile insect techniques.

List some insect pest situations for which sterile insect techniques have been successful in providing control.

G. Pesticides

Describe how the following terms relate to the toxicity and effectiveness of insecticides:

- mode of action;
- metabolization;
- uptake in plant (systemics);
- persistence;
- selectivity.

Compare/contrast contact vs. ingested insecticides.

Define:

- mode of action;
- persistence in the environment;
- selectivity;
- hormoligosis or reproductive stimulant.

Describe several nontarget hazards of insecticides.

Define Toxicity Categories as they apply to insecticides.

Describe various secondary effects associated with insecticide use.

For the following groups of insecticides identify the:

- mechanism of toxicity on target organisms;
- general impact on nontarget organisms;
- potential impact on humans;
- persistence and movement through the environment;
- effective period of action against the pest:
 - chlorinated hydrocarbons;
 - organophosphates;
 - carbamates;
 - pyrethroids;
 - insect growth regulators;
 - botanicals;
 - pheromone confusion and behavioral disruptants;
 - oils and soaps;
 - inorganics;
 - fumigants;

H. Pesticide Resistance

Define:

pesticide resistance;
cross resistance.

List various factors that affect the rate at which pesticide resistance develops.

Describe the role of selection pressure in the development of pesticide resistance.

Describe the role of genetic variability in the development of pesticide resistance.

Describe ways to detect pesticide resistance in the field.

I. Application Methods

Explain the importance of coverage in a pesticide application and give some examples of how to achieve effective coverage.

Calibrate a sprayer when given label rate in lbs./acre, acres to be treated, speed of sprayer, gallons (liquid) per acre, and spray tank volume.

Describe the importance of placement in pesticide applications and give some examples of different methods of placement.

Describe the following selective application methods and give an example of a pest situation in which each might be appropriately used:

spot treatments;
alternate rows;
outside coverage;
baits;
trunk banding.